Exports, Productivity, and Credit Constraints: A Firm-Level Empirical Investigation of China*

Zhiyuan Li† Miaojie Yu‡

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Abstract

Recent Melitz-type (2003) intra-industry heterogonous trade models argue that a firm's productivity has significant effects on the firm's exports. This paper examines how a firm's credit constraints as well as its productivity affect its export decisions. We imbed the firm's credit constraints into a Melitz-type general-equilibrium model by endogenizing the probability of the success of firm-specific projects. We show that, all else equal, it is easier for firms to enter the export market if (1) the probability of the success of their project is higher and consequently they have easier access to external finance from financial intermediaries; or (2) they have alternative sources, other than from financial intermediaries, to obtain funds. We test these theoretical hypotheses using firm-level data from Chinese manufacturing industries and find strong evidence supporting the predictions of the model.

JEL: F1, F3, D9, G2

Keywords: Credit Constraints, Heterogeneous Firms, Productivity, Trade

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†Department of Economics, University of California, Davis, 95616 CA. Email: zhyli@ucdavis.edu

‡China Center for Economic Research (CCER), Peking University, Beijing 100871, China. Phone: 86-10-6275-3109, Fax: 86-10-6275-1474, Email: mjyu@ccer.pku.edu.cn.

1 Introduction

A widely accepted belief about a firm's heterogeneous export behavior is that a firm with higher productivity would generate greater revenue and thus be able to shoulder the fixed costs of market entry (Melitz, 2003). This interpretation abstracts from financial frictions that may arise from the firm's access to liquidity or to external finance. In the presence of financial frictions, however, firms face different borrowing constraints, which could in turn affect their capabilities to finance the upfront entry costs. In addition, inward foreign direct investment (FDI) may provide an alternative source of low-cost funds and alleviate credit constraints faced by firms. These possibilities raise the following questions: How do firms' credit constraints affect their exports? Do credit constraints vary across firms' types?

This paper addresses the issue by providing a general-equilibrium Melitz-type (2003) model to analyze the impact of a firm's heterogeneous external finance capability on its exports. There are two main innovations in our theoretical model. First, firms' export projects have different probabilities of success. More importantly, the heterogeneous probabilities of success induce different capabilities of firms to obtain external finance from financial intermediaries. Secondly, different types of firms have different abilities to obtain low-cost funds from sources other than financial intermediaries. In particular, subsidiaries of multinational corporations are able to receive financial support from their parent firms to bypass domestic credit constraints.

Inspired by the theoretical predictions, we estimate the effect of a firm's credit constraints on its exports, using a very rich panel dataset of Chinese manufacturing firms over the period of 2000-2007. We obtain robust empirical evidence that firms with fewer credit constraints exports more, while controlling for the endogeneity of credit constraints. Overall, one percentage increase in a firm's interest expenditures, which is used as a proxy for the firm's capability to borrow, increases its exports by percentage, ceteris paribus. In addition, foreign-invested-enterprises (FIEs) in China export more and are less sensitive to the availability of external finance indicating that the presence of foreign capital does alleviate the credit constraints faced by firms. Finally, various sensitivity checks strongly support our empirical findings.

This work adds to a small but growing literature on trade and finance, including work done by, among others, Qiu (1999), Chaney (2005), Manova (2008), Muûls (2008), and Buch et al. (2008). Inspired by Melitz (2003), Chaney (2005) first introduced liquidity constraints into the heterogeneous firms model and predicted that firms with higher liquidity endowment would face fewer financial constraints and it would consequently be easier for such firms to enter the export market. As a pioneering work in the field, Chaney (2005) theoretically focused only on the impact of a firm's internal funds on its exports. Then, Manova (2008) took a step forward to consider financial contracts and asset tangibility in a framework of firm heterogeneity. She found that, using sector-level panel data of bilateral exports, those industries in more financially developed countries are more likely to export bilaterally and to ship greater volumes.

In addition, Muûls (2008) combined both liquidity endowments and external financial contracts into a general equilibrium model and showed that the credit rating, the Coface score from a credit insuring company, has significant effects on a firm's exports. However, Muûls's theoretical model assumes equal cost of external finance following Manova (2008). That is, the repayment required for an identical principal is the same across all firms. Last but not least, Buch *et al.* (2008) investigated the impact of credit constraints on exports and outward FDI, including firm heterogeneity in borrowing costs in a partial equilibrium framework. In retrospect, all these works have enriched our understanding of the impact of a firm's credit constraints on its export behavior.

Most of the previous studies assume that, other than productivity, firms are different only in terms of the principal amount they need to borrow. Once this amount is given, there are no differences in repayments. This stems from the assumption made by these studies that the default rates across firms are the same. Our work introduces two more sources of heterogeneous credit constraints. Project-specific risks lead to different borrowing capabilities and capital from foreign parent firms causes firms to be less dependent on external finance. These additional sources of credit constraints lead to a better fit to reality. Equally importantly, though some of the previous studies worked on firm heterogeneity theoretically, they estimated their models only at the country and sector level, in part due to data restrictions. In the present paper, we are able to test our theoretical predictions using disaggregated firm-level data from China.

These findings are of special interest because China's exports experienced unprecedented growth over the past decade whereas Chinese firms faced severe credit constraints. Over the period of 2000-2007, the annual growth rate of China's exports was 25%. However, according to the World Business Environment Survey during 1999-2000 and the Investment Climate Assessment surveys in 1999 and 2002, China was among the group of countries that had the worst financing obstacles (Claessens and Tzioumis, 2006). Our results suggest that easier access to external finance through financial intermediaries and/or FDI would make the engine of China's exports more powerful. Figure 1 illustrates this point. During 2000-2007, FDI is positively associated with exports across Chinese cities as shown in Figure 1A whereas interest expenditures are positively associated with exports across industries as shown in Figure 1B.

[Insert Figure 1 Here]

The remainder of the paper is organized as follows. Section 2 describes mechanisms by which a firm's credit constraints affect its exports. Section 3 constructs a model introducing a firm's heterogeneous access to external finance and the impact of external finance impact on the firm's exports. Section 4 presents the econometric specification and data. Section 5 discusses the estimation results and provides robustness checks. Section 6 concludes the paper.

2 Exploring the Impact of Credit Constraints on exports

The role of a firm's productivity in its exports has been discussed in the literature. The seminal work by Melitz (2003) highlights that the most efficient firms export and earn extra profits abroad. Less efficient firms can only serve the domestic market since the entry to the foreign market would generate losses due to fixed entry costs. In contrast, the least efficient firms die and exit from the market.

Inspired by pioneering works by Chaney (2005) and Manova (2008), in this paper we take a step forward to identify that a firm's credit constraints are one of the most important channels through which a firm's productivity affects its exports.

Firms have heterogeneous capabilities in obtaining external finance. Firms with higher productivity would be more capable of obtaining loans. The intuition is straightforward. First, the more efficient firms are expected to have higher probability of success in export projects. Thus for the same size loan and the same amount of repayment, financial intermediaries are more likely to extend loans to firms with higher productivity because it is more likely that the intermediaries will be repaid. With projects with low probability of success, investors expect higher risks and thus are reluctant to extend loans to these projects. Incapable of obtaining external finance, less efficient firms would face more severe credit constraints and might be prevented from entering the export market, or they have to export less if they also face credit constraints in financing variable costs as well.

In addition to borrowing from financial intermediaries, firms are able to finance internally with their domestic profits. Aside from this, one interesting observation is that the firm's type also plays a role to its access to alternative sources of finance. One good example is that foreign-invested-enterprises (FIEs) in China, compared with non-FIEs, may have easier access to funds from their parent firms.[1] As a result, FIEs are expected

[1] Héricourt and Poncet (2009) shows that inward foreign direct investment in China plays an important role in alleviating domestic firms' credit constraints. Similar evidence is provided by Harrison and McMillan (2003) using data from the Ivory Coast.

to export more given all other constants. Indeed, the share of exports by FIEs in China increased from 48% in 2000 to 57% in 2007. The average annual growth rate (i.e., 29.6%) is higher than that of China's total exports (i.e., 25%) during 2000-2007.

In summary, all else equal, it is easier for firms to enter the export market if they have higher productivity, easier access to external finance from financial intermediaries, or easier access to alternative sources of funds.

In this paper, we first theoretically show that firms that have higher probabilities of success probabilities, especially FIEs, are less financially constrained and thus less likely to be prevented from exporting. The intuition is that, when firms need to borrow from financial intermediaries, the low probability of success leads to high repayment requirements by the intermediaries to cover investment risks. This in turn increases the export threshold. Therefore, firms that otherwise are productive enough to export could be prevented from exporting due to higher requirements for repayment. FIEs that have access to alternative funds from their parent firms need to borrow less and are less sensitive to external finance. In this sense, FIEs are less credit constrained.

We evaluate the importance of access to external finance to firms' export behaviors by testing two hypotheses: (1) Firms for which it is easier to borrow from financial intermediaries export more; and (2) FIEs export more and are less sensitive to the availability of external finance from financial intermediaries. By choosing firms' interest expenditures as a proxy for firms' external financing capabilities, we are able to explore the nexus among interest expenditures, access to foreign capital, and exports. Equally importantly, we also pin down the effect of foreign capital access on exports through the channel of credit constraints. All the estimation results have the expected sign, are statistically significant and are robust to different specifications.

Finally, we address the endogeneity issue of the effect of the firm's exports on its interest expenditures. The main idea is that, with more exports, firms need more upfront fixed costs. We choose the scale-weighted money supply in the previous period as an instrument of interest expenditures. Various statistical tests confirm that the instrument is well justified. After controlling for endogeneity problems, interest expenditures are shown to have an even greater impact on firms' exports.

Motivated by these observations, in the next section we develop a general equilibrium model aimed at capturing the impact of a firm's credit constraints on its exports.

3 The Model

3.1 Domestic Demand and Production

The economy consists of two countries, Home and Foreign (henceforth foreign counterparts of the variables are denoted with an asterisk $*$). Labor is the only input factor for production. The population is of size L at home. There are two sectors. One sector produces a single homogeneous good that is freely traded. Production in this sector is characterized by constant returns to scale with $q_0 = wl_0$ where l_0 is the labor used to produce quantity q_0 of the good. Thus labor productivity in this sector determines the wage level, w at home. We assume that both countries produce in this sector and that wages are thus fixed by the productivity in this sector. The second sector produces a continuum of differentiated goods as in Melitz (2003). Each firm supplies one of these goods and is a monopolist of its variety.

As in Melitz (2003), consumers are endowed with one unit of labor and the preference over the differentiated good displays constant elasticity of substitution. The utility function of the representative consumer is

$$U = q_0^{1-\mu} \left(\int_{\omega \in \Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}\mu},$$

where ω denotes each variety and Ω is the set of varieties available to the consumer. The utility has a Cobb-Douglas form with share $1-\mu$ on the numeraire sector. The constant elasticity of substitution across each variety in the non-numeraire sector is denoted by

$\sigma\,(>1)$. The aggregate price index at home is thus

$$P = \left(\int\limits_{\omega \in \Omega} p(\omega)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}},$$

where $p\,(\omega)$ is the price of each variety. Accordingly, the demand for each variety is

$$q(\omega) = \mu w L \left(\frac{p(\omega)^{-\sigma}}{P^{1-\sigma}} \right)$$

and the revenue of each firm is

$$r(\omega) = \mu w L \left(\frac{p(\omega)}{P} \right)^{1-\sigma},$$

where wL is the total expenditure on the differentiated good at home.

Firms face a fixed cost of entering the domestic market (C_d), which can be fully financed by using their internal liquidity. The cost function of serving the domestic market is

$$c_d(q_d) = q_d \frac{w}{x} + wC_d,$$

where x is the productivity of the firm. As is common for monopolistic competition, each firm sets the domestic price, p_d, with a constant mark-up $\frac{\sigma}{\sigma-1}$ over the unit cost

$$p_d(x) = \frac{\sigma}{\sigma-1} \frac{w}{x}.$$

Therefore, firms generate profits at home:

$$\pi_d(x) = \frac{r_d(x)}{\sigma} - wC_d = \frac{\mu}{\sigma} wL \left(\frac{\sigma}{\sigma-1} \frac{w}{xP} \right)^{1-\sigma} - wC_d,$$

where $r_d(x)$ is the firms' domestic revenues. In order to survive in the domestic market, firms must have high enough productivity so that they can make positive profits. The cut-off productivity level, $\overline{x}_d$, is determined by the zero profits condition,

$$\pi_d(\overline{x}_d) = 0,$$

or

$$\overline{x}_d = \frac{\sigma}{\sigma-1} \frac{w}{P} \left(\frac{\sigma C_d}{\mu L} \right)^{\frac{1}{\sigma-1}}. \tag{1}$$

3.2 The Decision to Export

When a firm wants to export, the upfront fixed cost, wC_E, can be financed *internally* using a fraction, d, of its domestic profits π_d. Firms could also use a certain amount of zero-interest, zero-collateral funding from the parent firm if the firm is a FIE. Finally, they could raise funds externally from financial intermediaries.

For simplicity, we assume that FIEs' parent firms provide them a fraction of the fixed costs of the exports without interest, $\delta_i w^* C_E$, where $w^* C_E$ is the fixed cost of exports.[2] The parameter δ_i, $\forall i = F, NF$, is the fraction and F, NF are the FIEs and non-FIEs, respectively. We assume that $\delta_F > \delta_{NF} = 0$ given the fact that non-FIEs do not have alternative source of funds. If the project is successful, firms pay back this specific loan. Otherwise, the loss will be covered by the parent firms.

When firms borrow funds from financial intermediaries, they face different costs. First, the export project is subject to firm-specific risk and the probability of success, $\lambda(x) \in [0, 1]$, is public knowledge. $\lambda(x)$ is assumed to be an increasing function of a firm's productivity x.[3] Firms must offer investors a repayment, $G_E(x)$, such that investors can be breakeven. The minimum level of the repayment firms can offer depends on the project's probability of success.

The external funds lent by investors require pledgeable collateral in case that the project fails. The collateral that a firm can provide is a fraction of the domestic fixed cost, twC_d, where wC_d is the domestic fixed cost and t is the fraction of the fixed cost that is pledgeable. The firm will never default on the repayment if the project is successful. If the project fails, investors could get back only the collateral.

Financial contracting proceeds as follows. In the beginning of each period every firm makes a take-it-or-leave-it offer to a potential investor. This contract specifies the amount the firm needs to borrow, the repayment G_E in case the project is successful, and the

[2] For example, setting up a distribution network in foreign country requires foreign labor.

[3] The assumption that the probability of success is a function of productivity is only for the sake of theoretical simplicity. In reality, the probability of success of a project might be related to other variables.

collateral in case of failure. Revenues are then realized and the investor receives payments at the end of the period.

The firms maximize their expected export profits, subject to four constraints:

$$
\begin{aligned}
E\left(\pi_E(x)\right) \quad &= \quad \lambda(x)\left(p_E(x)q_E(x) - \frac{q_E(x)\tau w}{x} - (1-k_E)w^*C_E - G_E(x)\right) \\
&\quad -(1-\lambda(x))twC_d \\
\text{s.t.} \quad & \lambda(x)G_E(x) + (1-\lambda(x))twC_d = k_E w^* C_E \qquad (2) \\
& p_E(x)q_E(x) - \frac{q_E(x)\tau w}{x} - (1-k_E)w^*C_E \geq G_E(x) \\
& \frac{d\pi_d(x) + \delta_i w^* C_E}{w^* C_E} = 1 - k_E \\
& q_E(x) = \frac{\mu w^* L^* p_E(x)^{-\sigma}}{P^{*1-\sigma}}
\end{aligned}
$$

where τ is the iceberg transportation cost, $1 - k_E$ is the firm-specific fraction of the fixed cost that could be financed *internally* or through loans from parent firms of FIEs.

The first constraint is the investor break even equation, stating that investors are perfectly competitive so they receive zero profits. The second constraint indicates that, if the project is successful, the firm must have enough net revenue to pay the repayment $G_E(x)$ to the investors. Notice that if expected exports profits, $E(\pi_E(x))$, are greater than or equal to zero, this constraint is not binding. The third constraint specifies the portion of funds that need to be externally financed. Firms could use a fraction of domestic profits and loans from parent firms, if any, to cover part of fixed costs of the exports . Aside from these, the leftover, $k_E w^* C_E$, must be financed externally. The last constraint is the derived demand function.

This maximization problem thus provides the sources of credit constraints. First, in order to export and make a profit, firms must have the capability to generate large enough revenue so that they can offer a large enough repayment to investors. With a repayment that would allow investors to gain more than the break-even amount, investors would choose to extend financing to the firms. If the firm's productivity is too low, it cannot generate large enough profits and hence cannot offer repayments that will allow the investors to break even, and thus they will not get any financing. Secondly, for the same level of repayment, investors are more likely to extend financing to firms that have larger probabilities of success because it is more likely that they will be repaid. In sum, the easier for the firm to get external financing, the more likely that the firm enters the export market.

The investor's break-even equation determines the repayment that investors demand:

$$G_E(x) = twC_d + \frac{1}{\lambda(x)}\left(k_E w^* C_E - twC_d\right). \tag{3}$$

We substitute (3) into firm's expected profits

$$E\left(\pi_E(x)\right) = \lambda(x)\left(p_E(x)q_E(x) - \frac{q_E(x)\tau w}{x} - w^* C_E\right) - (1-\lambda(x))k_E w^* C_E.$$

This equation indicates that as long as firms need to borrow from investors, *i.e.*, $k_E > 0$, they must have higher expected profits to survive in the export market. The extra cost due to credit constraints depends on the amount they borrowed ($k_E w^* C_E$) and the probability of success of the project ($\lambda(x)$).

The expected profits maximization problem is thus equivalent to maximizing

$$\left(p_E(x)q_E(x) - \frac{q_E(x)\tau w}{x} - w^* C_E\right) - \left(\frac{1}{\lambda(x)} - 1\right)\left(\left(1-\delta_i\right) w^* C_E - d\pi_d(x)\right). \tag{4}$$

By defining the operating export profits as

$$\pi_E(x) \equiv p_E(x)q_E(x) - \frac{q_E(x)\tau w}{x} - w^* C_E, \tag{5}$$

the maximization problem is in turn equivalent to maximizing the operating exports profits since productivity, domestic profits, and the fraction of fixed costs covered by parent firms are *predetermined* from the perspective of the firms when they make export decisions.[4]

[4] An implicit assumption is that a firm's productivity leads to exports. That is, good firms export, which is a common assumption for all Melitz-type(2003) models.

Consequently, the results of Melitz (2003) such as the optimal price $p_E(x)$, the quantity $q_E(x)$, the operating exports profits $\pi_E(x)$, and revenue $r_E(x)$, hold for the active exporters:[5]

$$\begin{aligned}
p_E(x) &= \frac{\sigma}{\sigma-1}\frac{\tau w}{x} \\
q_E(x) &= \left(\frac{\sigma}{\sigma-1}\frac{\tau w}{x}\right)^{-\sigma}\frac{\mu w^* L^*}{P^{*1-\sigma}} \\
\pi_E(x) &= \frac{r_E(x)}{\sigma} - w^* C_E = \frac{\mu}{\sigma} w^* L^* \left(\frac{\sigma}{\sigma-1}\frac{\tau w}{x P^*}\right)^{1-\sigma} - w^* C_E \\
r_E(x) &= \mu w^* L^* \left(\frac{\sigma}{\sigma-1}\frac{\tau w}{x P^*}\right)^{1-\sigma}
\end{aligned}$$

Firms might or might not be restricted by credit constraints. If firms have high enough productivity so that they can generate high enough domestic profits, or if loans from parent firms are high enough, so that there is no need for externally raise funds, firms are not subject to credit constraints.

Without credit constraints, the threshold productivity level of the exporter, $\overline{x}_E$, is determined by $\pi_E(\overline{x}_E) = 0$, or

$$\overline{x}_E^{\sigma-1} = \left(\frac{\sigma}{\sigma-1}\frac{1}{P^*}\right)^{\sigma-1}\frac{\sigma}{\mu}\frac{1}{L^*}\frac{C_E}{(\tau w)^{1-\sigma}}. \tag{6}$$

Firms might face credit constraints. Firms with productivity level x such that

$$(1-\delta_i)\, w^* C_E - d\pi_d(x) > 0$$

need to borrow money externally in order to enter the exports market. Within these firms, only a subset could successfully enter the export market by making a positive expected export profits. Note that if $d \to 0$, all firms that want to export must raise funds externally. The capability of firms to secure external loans determines whether or not the firm can export. In order to make positive expected profits, firms must have a productivity level x

[5] Notice that exporting firms sell in the foreign market and thus the foreign price level (P^*), rather than the domestic price level, is present in the solutions.

such that

$$\pi_E(x) - \left(\frac{1}{\lambda(x)} - 1\right)\left[(1-\delta_i)\, w^* C_E - d\pi_d(x)\right] \geq 0$$

to survive the export market. Consequently, the cut-off productivity of exporting firms that are subject to credit constraints is determined by

$$\pi_E(\overline{x}_{CE}) - \left(\frac{1}{\lambda(\overline{x}_{CE})} - 1\right)\left[(1-\delta_i)\, w^* C_E - d\pi_d(\overline{x}_{CE})\right] = 0. \tag{7}$$

Compared to the cutoffs without credit constraints in Equ.(6), credit constraints virtually "increase" the fixed costs of exports for marginal firms, and hence the difficulty of entering the market increases. Solving this equation, the cutoff productivity for firms subject to credit constraints is:[6]

$$\begin{aligned}\overline{x}_{CE} \;=\; & \frac{\sigma}{\sigma-1}\left(\frac{\sigma}{\mu}\right)^{\frac{1}{\sigma-1}}\left(\frac{(1-\delta_i+\lambda(\overline{x}_{CE})\delta_i)\, w^* C_E}{\lambda(\overline{x}_{CE})} + \left(\frac{1}{\lambda(\overline{x}_{CE})} - 1\right) dwC_d\right)^{\frac{1}{\sigma-1}} \\ & \left(w^* L^* \left(\frac{\tau w}{P^*}\right)^{1-\sigma} + \left(\frac{1}{\lambda(\overline{x}_{CE})} - 1\right) dwL \left(\frac{w}{P}\right)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}.\end{aligned} \tag{8}$$

Firms with productivity below $\overline{x}_{CE}$ cannot export due to credit constraints, although some of them are sufficiently productive to do so profitably without credit constraints.

3.3 The Equilibrium

To examine the equilibrium, we assume that the price level only depends on domestic firms' prices and that foreign firms do not face any credit constraints by following Chaney (2005) and Muûls (2008). This assumption indicates that

$$P \approx \left(\int_{x \geqslant \overline{x}_d} p_d(x)^{1-\sigma} L dF(x)\right)^{\frac{1}{1-\sigma}}$$

where L is the home population and $F(x)$ is the cumulated density function of the firm's productivity at home. Given that the cut-off productivity level has an implicit form, we

[6] See the appendix for details.

define the function $h(\cdot)$ by:

$$h(\cdot) : \overline{x}^{\sigma-1} = \left(\frac{\sigma}{\mu} \int\limits_{x \geqslant \overline{x}} x^{\sigma-1} dF(x) \right) C \Longleftrightarrow \overline{x} = h(C)$$

with $h' > 0$. Assuming that the distribution of productivity is the same in the foreign country as at home, $F(x) = F^*(x)$, the function $h(\cdot)$ will be the same for the foreign country.

It turns out that the cutoffs in equations (1), (6), and (8) are solved as:[7]

$$\overline{x}_d = h(C_d), \tag{9}$$

$$\overline{x}_E = \left(\frac{C_E}{C_d^*} \right)^{\frac{1}{\sigma-1}} \frac{\tau w}{w^*} h(C_d^*), \tag{10}$$

$$\overline{x}_{CE} = \left(\frac{(1 - \delta_i + \lambda(\overline{x}_{CE})\delta_i) \frac{w^* C_E}{w} + (1 - \lambda(\overline{x}_{CE}))\, dC_d}{\tau^{1-\sigma} \left(\frac{w^*}{w} \right)^{\sigma} \lambda(\overline{x}_{CE}) C_d^* h^{1-\sigma}(C_d^*) + (1 - \lambda(\overline{x}_{CE}))\, dC_d h^{1-\sigma}(C_d)} \right)^{\frac{1}{\sigma-1}}, \tag{11}$$

where Equ.(11) indicates that $\overline{x}_{CE}$ is an implicit decreasing function of δ_i, which is denoted as $\overline{x}_{CE}(\delta_i)$.

From solutions (10) and (11), it is easy to show that $\overline{x}_{CE} = \overline{x}_E$ provided that $\lambda = 1$. Instead, if $\lambda = 0$, then $\overline{x}_{CE}(\delta_i)$ is the solution of equation $(1 - \delta_i)\, w^* C_E = d\pi_d(x)$, defined as $\overline{x}_{NEF}$, where NEF stands for "no external finance". This is because $\overline{x}_{NEF}$ is the cutoff productivity level with which firms' domestic profits and parent firms' loans are sufficient to finance their fixed costs to export. That is, firms with productivity above this level do not need any external finance. It is worth noting that when $d \to 0$ as in Manova(2008), $\overline{x}_{NEF} \to \infty$. In this case, all firms need external loans in order to export. The capability of obtaining loans determines the capability of firms to export.

When $\lambda \in (0, 1)$, $\overline{x}_{CE}(\delta_i)$ is in between of $\overline{x}_E$ and $\overline{x}_{NEF}$. From this fact, we can identify the sufficient condition such that there are some potential exporting firms prevented from exporting as stated in the following proposition.

[7] See the appendix.

Proposition 1 *If x is continuously distributed from $[0, \infty]$, and if*

$$\left((1-\delta_i) \frac{w^* C_d^*}{dw C_d} + \frac{C_d^*}{C_E} \right)^{\frac{1}{\sigma-1}} \left(\frac{h(C_d)}{h(C_d^*)} \right) > \frac{\tau w}{w^*}$$

then there exists a non-empty set of firms which are prevented from exporting even though they are profitable enough to do so if without credit constraints.

Proof. *This proposition can be easily proved by substituting equation (11) and (10) into inequality $\overline{x}_E < \overline{x}_{CE}(\delta_i)$ and making $\lambda = 0$.* ■

Proposition 1 suggests that, when the fraction of domestic profits used to finance the fixed costs to export is close to zero ($d \to 0$), then there are always firms that are prevented from exporting. This is very realistic because firms might not be able to use a large portion of domestic profits to finance export projects. One example of this is that in the presence of principal-agent problems, stockholders may demand dividends at the end of each period instead of entrusting management with the utilization of retained earnings. This indicates that the capability of obtaining external finance is essential in determining whether or not firms could export.

Figure 2 illustrates firms' exporting behaviors. The vertical axis is the expected export profits and the horizontal axis is the productivity. The E_M curve is the expected export profits curve if there is no financial friction, as in Melitz(2003). Firms with a productivity level greater than $\overline{x}_E$ can profitably export if there is no credit constraint. However, when there are financial frictions, some of these firms can no longer export because they cannot obtain external loans to finance the fixed costs to export. Curves E_F and E_{NF} are the expected exports profits curves for FIEs and non-FIEs, respectively. Thus, potential FIE exporters and potential non-FIE exporters that are prevented from exporting are firms with productivity levels in the range of $[\overline{x}_E, \overline{x}_{CE}(\delta_F)]$ and $[\overline{x}_E, \overline{x}_{CE}(\delta_{NF})]$ respectively. These firms cannot offer large enough repayments to investors and consequently cannot obtain external loans. Thus, they are prevented from exporting. Instead, FIEs and non-FIEs with productivity levels greater than $\overline{x}_{CE}(\delta_F)$ and $\overline{x}_{CE}(\delta_{NF})$, respectively, are able to obtain external loans and enter the export market. Firms with productivity levels greater than $\bar{x}_{NEF}$ have sufficient domestic profits to finance the fixed costs to export internally and need not borrow from investors. However, as noted above, if the fraction of domestic profits that can be used to finance an export project is sufficiently small, then all exporting firms are subject to credit constraints. Firms' capabilities of obtaining external loans then determine their capabilities of exporting.

[Insert Figure 2 Here]

Therefore, our model predicts that firms face different levels of credit constraint. The credit constraints are related to firms' previous domestic profits. They affect the amount of internal liquidity that can be used to finance the entry costs to export as suggested by Chaney (2005). Aside from this, there still exist other important channels that affect firms' credit constraints.

First, firms with higher productivity are more capable of obtaining external loans. Higher productivity firms would generate larger export revenues and thus they would be able to offer a larger repayment for the same amount of principal. Thus they are less credit constrained. More importantly, the higher productivity introduces the higher probability of success of the projects. As a result, investors are more likely to break even when they extend loans to more productive firms, given the level of the principal and the repayment. Investors thus would be more inclined to extend loans to more productive firms. Less productive firms are then prevented from entering the export market. Again, the capability of obtaining external loans is the key to exporting in the presence of financial frictions.[8]

Secondly, our model clearly suggests that the firm's type plays a role in its access to alternative funds, which in turn affects the firm's export decision. Since $\overline{x}_{CE}(\delta_i)$ is a

[8] Of course, in reality, a firm's capability of raising funds externally may be affected by other factors such as automatic customer insolvency, bad debts, overdue accounts, commercial risks, and even political risks. However, the key lesson is that firms that are capable of obtaining external loans will be able to export.

decreasing function of δ_i, firms that have atlternative channels (*e.g.*, FIEs get loans from their parent firms) to obtain low-cost loans would depend less on external financing from financial intermediaries and thus have lower requirements of productivity levels to enter the export market. Given that $\delta_F > \delta_{NF}$ as assumed, FIEs might be able to export more compared to non-FIEs even when they both have the identical loans from financial intermediates, while otherwise they would be prevented from exporting. In sum, we make the following proposition:

Proposition 2 *All else equal, it is easier for firms to ente the export market if (1) they have higher probability of success of the project and consequently easier access to external financing from financial intermediaries; or (2) they have alternative sources, other than from financial intermediaries, to obtain funds.*

4 Econometrics, Data, and Measures

In this section, we first discuss the empirical specifications, followed by a description of the dataset used in the paper. We then present the results and address the possible endogeneity problem. Finally, we close the section with various robustness checks.

4.1 Empirical Specfication

Our theoretical model introduced above clearly predicts that it is easier for firms with higher probability of success to get loans from financial intermediaries and it is thus easier for them to enter the export market. Put another way, the model predicts that firms with larger interest expenditures, an index of their capability of obtaining loans, would export more. In addition, firms with higher productivity also export more. We therefore consider a specification as follows:

$$\begin{aligned} \ln EX_{it} &= \beta_0 + \beta_1 \ln IE_{it} + \beta_2 \ln TFP_{it-1} + \beta_3 FIE_i \\ &\quad + \beta_4 FIE_i \ln IE_{it} + \beta_5 \ln Dprof_{it-1} + \boldsymbol{\theta}\mathbf{X}_{it} + \varsigma_i + \vartheta_t + \epsilon_{it}, \end{aligned} \quad (12)$$

where i is the firm and t denotes year, $\ln EX$, $\ln IE$, and $\ln TFP$ are the firm's log exports, log interest expenditures, and log total factor productivity, respectively. FIE_i is a dummy variable, equal to a unit if firm i is a foreign-invested-enterprise and zero otherwise. Interest expenditures, TFP and FIE status all are predicted to contribute to exports. Thus coefficients, β_1, β_2 and β_3, all are expected to be positive. The coefficient of the interaction term of FIE and $\ln IE$ captures the differential impact of interest expenditures on exports for different types of firms. The model suggests that FIEs are less dependent on external borrowing. Thus, $\hat{\beta}_4$ is expected to be negative.

Firms might also be able to finance the fixed costs to export using domestic profits. In order to capture this, we also include in the firms' log domestic profits ($\ln Dprof$). Since domestic profits as well as productivity are both predetermined before the firms make export decisions, we include values for the previous period for $\ln TFP$ and $\ln Dprof$ in the empirical specification (12).[9] In contrast, current period interest expenditures affect firms' exports, Thus, we use its current realization in the empirical model.

In addition, $\mathbf{X}$ denotes other control variables. In particular, traditional wisdom says that SOEs in China play a significant role on its economy, although this is not formally specified in the theoretical model. To shed light on this point, we also include a dummy for SOEs and its interaction term with interest expenditures, $SOE_i \times \ln IE_{it}$, in the model.

Finally, all other unspecified factors are absorbed in the error term, which can be decomposed into the three following components: (1) firm-specific fixed effects ς_i to control for time-invariant factors; (2) year-specific fixed effects ϑ_t to control for firm-invariant factors; and (3) an idiosyncratic effect ϵ_{it} with normal distribution $\epsilon_{it} \sim N(0, \sigma_i^2)$ to control for other unspecified factors. The impact of credit constraints on exports is the focus of this paper; thus the coefficient of β_1 is our main interest.

[9] This setup also enjoys an extra advantage that we do not need to worry about the reverse causality of exports and productivity in the estimations.

4.2 Data

The sample used in this paper comes from a rich firm-level panel dataset which covers more than 160,000 manufacturing firms per year for the years 2000-2007. The number of firms doubled from 162,885 in 2000 to 336,768 in 2007. The data are collected and maintained by China's National Bureau of Statistics in an annual survey of manufacturing enterprises. It covers two types of manufacturing firms: (1) all SOEs; (2) non-SOEs whose annual sales are more than five million *yuan*.[10] The dataset includes more than 100 financial variables listed in the main accounting sheets of all these firms.[11]

Although this dataset contains rich information, a few samples in the dataset are noisy and misleading due, in large part, to the misreporting by some firms.[12] For example, information on some family-based firms, which usually did not set up formal accounting systems, is based on a unit of *one yuan*, whereas the official requirement is a unit of 1,000 *yuan*. Following Jefferson *et al.*(2008), we clean the sample and rule out outliers by using the following criteria: first, observations whose key financial variables (such as total assets, net value of fixed assets, sales, gross value of industrial output) cannot be missing; otherwise, they will be dropped. Secondly, the number of employees hired for a firm must not be less than 10 people[13].

Following Cai and Liu (2009), and guided by the General Accepted Accounting Principles (GAAP), we delete observations if any of the following rules are violated: (1) the total assets must be higher than the liquid assets; (2) the total assets must be larger than the total fixed assets; (3) the total assets must be larger than the net value of the fixed assets; (4) a firm's identification number cannot be missing and must be unique; and (5)

[10] Indeed, aggregated data on the industrial sector in the annual *China's Statistical Yearbook* by the Natural Bureau of Statistics (NBS) are compiled from this dataset.

[11] Following Levinsohn and Petrin (2003), plants were treated as firms. In the present paper, we do not capture scope economics due to their multi-plant nature. This remains a topic for future research.

[12] Holz (2004) offers careful scrunity on possible measurement problems in Chinese data, especially on the aggregated level.

[13] Levinsohn and Petrin (2003) suggest covering all Chilean plants with at least 10 workers. Here, we follow their cretirion.

the established time must be valid. In particular, observations in which the opening year is after 2007 or the opening month is later than December or earlier than January are dropped as well.

Since FIEs as well as SOEs play a significant role in our model, it is an advantage to take a careful look at these firms. We first construct a dummy for foreign-invested firms ($FIEs$) to distinguish domestic from non-domestic firms. Here, we consider a broad classification of FIEs. In particular, the FIEs include both foreign firms and Hong Kong/Macao/Taiwan (H/M/T)-owned firms.[14] In a robustness check, we consider a narrower classification of FIEs by excluding the H/M/T-owned firms. Turning to the dummy for SOEs,[15] to avoid a possible "adverse selection" problem faced by small SOEs in borrowing external loans, we use "above-scale" SOEs as a default sample by dropping SOE observations whose operation scales are smaller than the "above-scale" threshold. In particular, the observations are dropped if any of following indicators is lower than 5 million *yuan*: (1) the value of the firm's sales; or (2) the value of the total assets; or (3) the value of the fixed assets. In robustness checks, we include all SOEs.

After this very rigorous filter, we obtain a sample of $1,294,596$ observations from the original sample of $1,898,958$, which accounts for 69.2% of the original dataset.[16] All nominal terms are originally measured in current Chinese *yuan*. We therefore use the producer price index (PPI) by sector, which is measured at the two-digit Chinese industrial classification and obtained from the National Bureau Statistics, as the GDP deflator by choosing year 2000 as the base year.

[14] Specifically, FIEs include the following firms: foreign-invested joint-stock corporations (code: 310), foreign-invested joint venture enterprises (320), fully foreign-invested enterprise (330), foreign-invested limited corporations (340), H/M/T/ joint-stock corporations (code: 210), H/M/T joint venture enterprises (220), fully H/M/T-invested enterprises (230), and H/M/T-invested limited corporations (340).

[15] By definition, SOEs include firms such as domestic SOEs (code:110); state-owned joint venture enterprises (141); state-owned and collective joint venture enterprises (143); and state-owned limited corporations.

[16] Including small- and medium- sized SOEs whose scales are lower than the threshold would increase our sample to 1,401,569, which accounts for around 73.8% of the original size of the dataset.

Panel A of Table 1 provides some basic statistical information about the Chinese firm data. After the filter, the number of "above-scale" FIEs is $273,160$, which accounts for 21.1% of the full samples. In particular, the number of FIEs excluding H/M/T-owned firms is $132,826$, 10.2% of all "above-scale" firms. The remaining 79% are domestic firms, of which 9.1% are SOEs and 5.8% are "above-scale" SOEs.

[Insert Table 1 Here]

In the sample, some firms export while some do not. Only $360,106$ firms have positive exports, which accounts for 27.7% of all "above-scale" firms. However, $880,026$ firms, a 67.3% of all firms, have positive interest expenditures. We plot the logarithm of exports against the logarithm of interest expenditures at the SIC 2-digit industrial level as shown in Figure 1B. We can clearly observe a positive correlation between exports and interest expenditures across sectors. It seems difficult to find obvious outliers in the scatter plots. This suggests that the positive correlation between the two is unlikely due to outliers.

Finally, a firm's domestic profits are measured as the difference between the firm's overall profits and its export value. A firm's productivity is measured by using both total factor productivity (TFP) and labor productivity. In particular, the measure of TFP, by definition, requires that firms' output be measured by real but not nominal terms. Following Amiti and Konings (2007), we therefore use China's PPI at the SIC 2-digit level as the deflator to convert data from nominal terms to real terms. To be consistent with other data, the base year of the deflator is also chosen as 2000.

4.3 Measures of TFP

As one of the most important control variables in our regressions, it is essential for us to measure TFP precisely. However, many existing works on measuring TFP show that it is imprecise and biased (Amiti and Konings, 2007).

TFP is usually measured as the Solow residual, defined as the difference between the observed output and its fitted value calculated via OLS. However, this method suffers from two biases: a simultaneity bias and a selection bias. The first bias comes from the fact that a profit-maximizing firm would readjust its input decision as a response to productivity shocks that are observed by firms but not by econometricians. Second, all firms covered in the samples are those that have relatively high productivity and survived during the period of investigation. Those firms that had low productivity, shut down, and left the market were not observed nor included in the sample. Put another way, the sample covered in the regressions is not randomly selected. Hence, all related estimates would suffer from a selection bias.

To overcome these two empirical challenges, we use the augmented Olley-Pakes (1996) approach to estimate and calculate the firms' TFP. Given China's WTO accession in 2001, which was a positive demand shock for China's exports, we also include a WTO dummy in the Olley-Pakes estimations to capture the effect of the WTO accession. We report the detailed estimation procedure in Appendix B.

Appendix Table B also presents the estimated survival probability of the firms in the next year by industry at the SIC 2-digit level. Its mean of 0.993 suggests that the problem of firms' exiting is not so severe during this period. The rest of Appendix Table B reports the difference in the estimated coefficients for labor, material, and capital by using a regular OLS approach and the OP methodology. We cover 36 manufacturing industries coded from 6 to 46, according to China's new industrial classifications (GB/T4754), which were adopted in 2002.[17] Compared to the original firm-level dataset, four industries are not covered after this filter process.[18]

[17] Firm data before 2002 were clustered into industrial data by adopting the old industrial classification. We concord such data so that they are consistent with data after 2002.

[18] The five industries dropped include extraction of petroleum and natural gas (7), mining of other ores (11), processing of food from agricultural products(12), and recycling and disposal of waste (43).

5 Empirical Results

5.1 Main Estimation Results

Table 2 presents the estimation results for equation (12). To consider the effect of a firm's interest expenditures on its exports, we first run a simple OLS regression of firms' exports on firms' log interest expenditures, log TFP in the previous year, and FIE dummy as a benchmark. The estimated coefficient $\hat{\beta}_1$ in equation (12) is .290, which is significant at the conventional statistical level. This suggests that a one percentage increase in a firm's interest expenditures is associated with a .290 percentage increase in its exports. The benchmark finding is consistent with the simple cross-sectional plot in Figure 1B. The positive effect of TFP is also consistent with the previous findings like those of Bernard and Jensen (1999) that firms with higher productivity export more.

In Column (1), we also observe that FIEs are shown to export more than non-FIEs. However, the finding that FIEs have more exports could be due to their quick learning, better technology adoption, or higher quality inputs (Amiti and Konings, 2007), or even simply because they are established to export *per se*. However, FIEs might export more because of their easier access to low-cost loans (*e.g.*, financial support from their parent firms). If this is correct, FIEs should be less sensitive to external finance. Similarly, it is also interesting to ask whether SOEs export more compared to non-SOEs and check whether or not they are sensitive to external finance.

We then consider a specification including four more variables: the SOEs dummy, the interaction terms between FIEs and the log interest expenditure ($FIE_i \times \ln IE_{it}$) and between SOEs and log interest expenditures ($SOE_i \times \ln IE_{it}$), and the firm's log domestic profit in the previous period ($\ln Dprof_{it-1}$). The OLS estimation results show that the interaction term between FIEs and interest expenditures is negative, which suggests that exports of FIEs, compared to those of non-FIEs, are less sensitive to external finance. The variable of FIEs itself is positively correlated with exports as expected. In addition, the significantly positive sign of a firm's domestic profits is consistent with the prediction suggested by the theoretical model: firms with high predetermined domestic profits do not suffer from credit constraints as much and hence they export more.

In addition, the significant negative sign of SOEs suggests that SOEs, compared to non-SOEs, do not export more. There exist several possible reasons for this finding. First, China's SOEs may suffer from an inefficient incentive mechanism (Lin, 2003). Secondly, the SOEs enjoyed less preferential treatment in access to external finance after China's WTO accession in 2001 (Bajona and Chu, 2004). Accordingly, SOEs have lower productivity and export less.

[Insert Table 2 Here]

Aside from the variables introduced above, other variables may affect a firm's exports as well, though they are not specified in the theoretical model for simplicity. Such variables include time-varying but firm-insensitive factors like Chinese *yuan* (RMB) appreciation.[19] Similarly, some other unspecified time-invariant but firm-varying factors like a firm's location may also have impact on the firm's exports. To control for such factors, we include both year-specific and firm-specific fixed effects in the estimations.

Columns (3) and (4) of Table 2 report the fixed-effect estimation results. Since the dummies of FIEs and SOEs are time invariant, they are automatically dropped from the estimations. In all specifications, the firm's TFP is shown to be significantly positively associated with its exports. The key coefficients $\hat{\beta}_1$ are all positive and significant at the conventional statistical levels. In terms of economic magnitude, the coefficients of the firms' interest expenditures in Columns (3) is much smaller than the coefficients in Column (1). However, after including more control variables, $\hat{\beta}_1$ in Column (4) is close to its counterpart in Column (2). Aside from this, most other control variables in Columns (1)-(4) have the expected signs, though they are insignificant. We suspect that the in-

[19] Chinese *yuan* was revaued against the US dollar by around 20% during 2005-2007.

significance is due to the lack of a control for the endogeneity of interest expenditures, which will be handled shortly.

5.2 The Zero Trade Problem

As mentioned above, more than 73% of firms had zero exports in our sample. Recent works like those by Santos Silva and Tenreyro (2006), Helpman *et al.* (2007), and Yu (2009) have argued that OLS estimates can lead to serious biases due to zero trade volume. The log-linearization of firms' exports may cause some bias since the entire portion of the data with zero trade is dropped. In addition, the zero trade problem in our study could reflect the rounding down of firms' exports, which creates an endogenous censoring problem.

To address the empirical challenges raised by the zero trade problem, Santos Silva and Tenreyro (2006) proposed a truncated Poisson pseudo-maximum likelihood (PPML) estimation to address the zero trade problem. We therefore perform the PPML fixed-effects estimation by adopting firms' exports EX_i directly as the regressand. As shown in Column (5) of Table 2, the coefficients of interest expenditures and TFP are still significantly positive in the PPML fixed-effects estimates. Compared to the OLS fixed-effects estimates in Column (4), the coefficient of the predetermined domestic profits turns out to be highly significant with the expected sign. The interaction term between interest expenditures and SOEs turns to be significantly negative. However, the interaction term between FIEs and interest expenditures has a strikingly positive sign. We again suspect that this is due to the lack of consideration of the endogeneity of interest expenditures. We now turn to this issue.

5.3 Endogeneity Issues

A firm's interest expenditures are not exogenously given, but affected by its exports. With more exports, firms need more upfront fixed costs (*e.g.*, firms need to have a greater distribution network abroad when its exports increase), which in turn require firms to obtain more debt to do business. One needs to control for the endogeneity of interest expenditures in order to obtain accurate estimated effects of a firm's interest expenditures on exports. Otherwise, the related estimates would be suspect. Instrumental variable (IV) estimation is a powerful econometric method that can address this problem.[20]

An economic indicator, a firm's weighted monetary supply, is constructed to serve as the instrument for interest expenditures. This indicator is defined as $(l_{ijt-1}/\sum_{i\in j} l_{ijt-1})M1_{t-1}$, where l_{ijt-1} is the number of employees of firm i in industry j, $\sum_{i\in j} l_{ijt-1}$ is the total number of employees in industry j, and $M1_{t-1}$ is China's base monetary supply ($M1$) in the previous year $t-1$. The last row in Table 1 lists the basic statistical information for this indicator.[21]

The intuition is straightforward. Monetary expansion increases the supply of investments, making external finance less costly. As a result, firms would finance more externally and interest expenditures would increase. Moreover, marginal firms, *i.e.,* previous credit constrained firms, are now able to borrow from financial intermediaries and they might be able to enter the export market. Since the money supply is exogenous to exports but it affects interest expenditures, it makes good economic sense to use it as an IV. We note that the previous-period money supply is used to construct the IV based on the fact that the monetary policy has a time lag to take effect.[22]

However, the effects of monetary expansion on external finance are not homogeneous across firms. Larger firms might be more competitive in the competition for loans and thus they may enjoy larger benefits from easier access to external finance. We therefore

[20] The IV approach is a good way to control for endogeneity issues. Wooldridge (2002, Chapter 5) provided a careful scrutiny of this topic.

[21] For robustness, we construct an alternative indicator using a firm scale, relative to the total economy, as a weight of the monetary supply. The results are similar.

[22] One may worry that monetary expansion might not affect the external finaning of small-sized firms in China, because they might not have any access to formal financial intermediaries whatsoever. However, this is not a severe problem for two reasons. First, monetary expansion stimulates investments from *informal* financial intermediaries as well. Small-sized firms would have easier external financing from these intermediaries following a monetary expansion. Secondly, all observation used in the default sample are "above-scale" firms, which usually have access to formal financial intermediaries. We will include small- and midium-sized firms later for robustness check.

consider a firm's relative size when constructing the IV. One might worry that a firm's sales, a usual index for measuring a firm's scale, is highly correlated with the dependent variable (*i.e.*, the firm's exports) and hence not exogenous. We address this concern by using the number of employees as a proxy for a firm's size. More importantly, we use its industrial weight, $l_{ijt-1}/\sum_{i\in j} l_{ijt-1}$, rather than the national economy's weight, to control for firm size.[23] In this way, it is less likely that the *level* of exports is highly correlated with the weight. Indeed, their simple correlation is very small in our sample ($corr = .04$). Also, as observed in Panel B of Table 1, the log of the weighted money supply has a small simple correlation with the log of exports ($corr = .39$), which is much lower than the simple correlation between the log of the weighted money supply and the log of the interest expenditure ($corr = .49$).

We perform several tests to verify the quality of our instrument. First, we checked whether the excluded instrument (*i.e.*, the firm's weighted monetary supply) is "relevant". That is, whether this instrument is correlated with the endogenous regressor (*i.e.*, interest expenditures). In our econometric model, the error term is assumed to be heteroskedastic: $\epsilon_{it} \sim N(0, \sigma_i^2)$. Therefore, the usual Anderson (1984) canonical correlation likelihood-ratio test is not valid since it only works under the *i.i.d.* assumption. Instead, we use the Kleibergen-Paap (2006) Wald statistic to check whether or not the excluded instrument is correlated with the endogenous regressors (*i.e.*, interest expenditures). The null hypothesis that the model is under-identified is rejected at the 1% significance level.

Secondly, we also tested whether or not the weighted monetary supply is weakly correlated with interest expenditures. If so, then the estimates will perform poorly in the IV estimate. The Kleibergen-Paap (2006) F-statistics provide strong evidence to reject the null hypothesis that the first stage is weakly identified at a highly significant level.[24]

[23] The reason for using industrial weight and not national weight ($l_{it-1}/\sum_i l_{it-1}$) is that, in China, the competition to borrow from banks is usually stronger in the same industry. However, using a national weight to construct the IV also delivers very similar findings, which are not reported here to save space but available upon request.

[24] Note that the Cragg and Donald (1993) F-statistic is no longer valid since it only works under the

Third, the Anderson and Rubin (1949) χ^2 statistics reject the null hypothesis that the coefficient of the endogenous regressor is equal to zero. In short, these statistical tests give sufficient evidence that the instrument performs well, and therefore, the specification is well justified.

The IV fixed-effects estimates in Columns (1) and (2) of Table 3 show that, after controlling for endogeneity, interest expenditures still have a positive effect on a firm's exports. In particular, the corresponding coefficients of the IV (*i.e.*, the logarithm of the lagged weighted money supply) in the first stage are also statistically significant and positive as expected. Their first-stage excluded F-statistics are definitely high enough to pass the F-tests. The coefficients $\hat{\beta}_1$ are higher than their counterparts in Table 2 without controlling for the endogeneity. The elasticity of a firm's interest expenditures on its exports is around a unit, which clearly suggests that high interest expenditures lead to more exports.

Equally important, in Column (2), the interaction term between FIEs and interest expenditures is $\hat{\beta}_4 = -.256$, which is significant at the conventional level, indicating that FIEs face less severe credit constraints. On average, a one percentage increase of non-FIEs' interest expenditure leads to a 1.068 percentage increase in its exports, *ceteris paribus*. By way of comparison, a one percentage increase in an FIE's interest expenditures leads to a .812 percentage increase in its exports since $1.068 - .256 = .812$. Similarly, the interaction term between SOEs and interest expenditures is significantly negative, which is consistent with the PPML fixed-effect finding in Table 2. The economic rationale, arguably, is that, compared to non-SOEs, SOEs are less sensitive to external finance due in part to their relatively easier access to subsidies or low-cost loans from the government.

After controlling for the endogeneity and fixed effects, the coefficient of domestic profits in Column (2) has a very small magnitude with an unexpected but insignificant sign. To some extent, this serves as side evidence that domestic profits is not a important channel

i.i.d. assumption.

through which firms finance their fixed costs for exports. Instead, the main channel to alleviate the credit constraints is borrowing externally.

[Insert Table 3 Here]

5.4 Additional Robustness Checks

5.4.1 Estimates with Narrower Definition of FIEs

As discussed above, being an FIE is important to a firm's exports in the sense that being such can introduce alternative financing channels such as funding from parent firms. To shed light on this point, we use a broad classification of FIEs in the estimations above. That is, firms with funding from H/M/T are considered as foreign-invested firms. Given that Hong Kong is one of the most important sources of China's foreign direct investment, our estimations so far thus provide a upper bound for the role of FIEs in exports. Yet, it is still a plus to understand the effect of FIEs on exports if we exclude the impact of funding from H/M/T.

We therefore redefine a narrow classification of FIEs by excluding H/M/T-owned firms and present the corresponding estimation results in Column (3) of Table 3. Compared with the findings in Column (2) using the broad definition of FIEs, the effect of interest expenditures is slightly larger: $\hat{\beta}_1 = 1.123$. In contrast, the effect of the interaction term, $FIE_i \times \ln IE_{it}$, is much lower. These findings together suggest that a one percentage increase in FIEs' interest expenditures leads to a percentage increase in its exports since $1.123 - .157 = .966$. This makes good economic sense. With fewer alternative channels through which to raise financing, firms, on average, have to rely much more on external borrowing to finance their fixed costs for exports.

5.4.2 Estimates Using "All-Scale" Data

As mentioned above, the data used for the estimations above are all "above-scale" because they include firms with annual sales higher than 5 million yuan. One advantage of using all "above-scale" data is to avoid a possible "adverse selection" problem. In China, it is difficult for small- and medium-sized firms to obtain external funds since financial intermediaries like banks are usually unwilling to lend to them due to the high risk of default. However, large firms usually do not have this problem.

The trade-off of using "above-scale" data is that the role of SOEs is over-estimated since some small- and medium-sized SOEs are dropped. Equally importantly, the problem of the exiting of firms cannot be well controlled: it does not necessarily mean that a large firm that was included in the early years of the study period but is not included in the later years and exited from the market. It could be just that its scale is smaller in the later period than the “above-scale” threshold and hence not counted in the truncated dataset.

As observed in Table 1, once we consider the small- and medium-sized SOEs, the number of SOEs increases to $127,598$, which accounts for 9.1% of the sample. When including small- and medium-sized SOEs, we first recalculated firms' average Olley-Pakes(1996)-type TFP, and then performed all related estimations. The results are reported in Column (4) Table 3. All coefficients have identical signs as the previous findings. The effect of interest expenditures for non-FIEs on exports, $\hat{\beta}_1$, is shown to be smaller than the estimates using the "above-scale" data. However, the effect of interest expenditures for FIEs on exports, $\hat{\beta}_1 + \hat{\beta}_4$, are insensitive to the estimation results using the "above-scale" data. In any case, our previous findings of the positive impact of interest expenditures on exports is robust.

5.4.3 Estimates without Productivity

Regardless of different empirical specifications, all the estimates from Tables 2 and 3 show that higher productivity leads to more exports. Our theoretical model also clearly shows that a firm's pre-realized productivity is the main driving force for exporting. With higher productivity, the probability of success is higher a firm's project, which in turn helps the firm to secure outside loans and to export more. In short, credit constraints are one of the channels by which firm's productivity affect its exports.

It is interesting to consider the *importance* of the channel of credit constraints in relation to other channels. After controlling for fixed effects and reverse causality of interest expenditures, Column (2) of Table 3 shows that the economic magnitude of interest expenditures is much higher than TFP (*e.g.*, in column (5), $\hat{\beta}_1 = 1.068$ whereas $\hat{\beta}_2 = .156$) .

This raises a question: if ignoring the impacts of other channels of productivity on exports, do credit constraints pick up the residual effects of productivity on exports? If so, then our estimations would be suspect since they are sensitive to different specifications. By dropping the variable of productivity, Columns (1)-(3) of Table 4 provide more evidence on this point. We report the estimation results using different econometric methods: OLS, Fixed-Effects, and Fixed-effect IV. All of the results obtained from these methods are not substantially quantitatively different from their counterparts in Tables 2 and 3. In particular, the IV fixed-effect estimates in Column (3) of Table 4 show that the magnitude of interest expenditures by excluding the variable of TFP, $\hat{\beta}_1 = 1.063$, is almost identical to its counterpart in Column (2) of Table 3 with the presence of TFP: $\hat{\beta}_1 = 1.068$. This thus provides strong evidence that interest expenditures do not pick up the residual effect of productivity on a firm's exports.

[Insert Table 4 Here]

5.4.4 Estimation with Labor Productivity

In the previous section, we use total factor productivity (TFP) to measure productivity since it is close to reality. However, since our theoretical model essentially is a one-input (i.e., labor) Krugman (1979) model, it is useful to use labor productivity to measure productivity as well. Columns (4) and (5) of Table 4 report the estimation results using labor productivity to measure productivity.

As shown in Column (4), with the control of both firm-specific and year-specific fixed effects, the coefficient of labor productivity, .174, is smaller than its counterpart in Column

(4) of Table 2: .204. The result makes good economic sense given that labor is only one of the inputs. After controlling for the endogeneity of a firm's interest expenditures, the IV fixed-effects estimates in Column (5) also present the anticipated positive sign. However, it is insignificant, which in turn suggests that the TFP may be a more ideal measure of a firm's productivity.

5.4.5 Additional Estimates with Ratio Specifications

Thus far, all estimates suggest that high interest expenditures lead to more exports. Yet, the key variables in the estimates above are measured by levels. It is useful to consider estimations with ratio specifications to check if our previous findings hold. We therefore take the log ratio of a firm's exports to its sales as the regressand. By the same token, we construct the log ratio of interest expenditures to sales and the log ratio of domestic profits to sales as the regressors. We then perform the Fixed-effects and IV fixed-effects estimations to reconsider the impact of credit constraints on exports.

Columns (1) of Table 5 presents the fixed-effects estimation results for our three key variables: interest expenditures, TFP, and the interaction term between interest expenditures and FIEs. We can clearly observe that, even when measured in ratios, all coefficients still have the anticipated signs and are statistically significant. Adding more control variables in Column (2) does not change our findings qualitatively. After controlling for the endogeneity issue, estimates in Columns (3) and (4) are still in line with our previous findings. The only slightly surprising finding is that, in Column (4), the coefficients on the ratio of interest expenditures to sales and TFP are insignificant. However, they still have the anticipated positive signs. In sum, all our robustness checks suggest that our findings are robust regardless of specification.

[Insert Table 5 Here]

6 Concluding Remarks

In this paper, we first constructed a theoretical model to consider how a firm's credit constraints affect its exports. Firms with higher productivity have higher probabilities for success of its projects. They thus are more capable of obtaining external finance from financial intermediates. Consequently, they are less credit constrained and are able to export more abroad. Moreover, FIEs are less sensitive to the availability of external finance since they have access to funds from their foreign parent firms.

We then test the theoretical predictions using a very rich Chinese firm-level dataset. After controlling for productivity and the endogeneity of a firm's capacity for external borrowing, we find strong empirical evidence to support our theoretical argument. In particular, firms that are more capable of obtaining external finance are shown to have higher levels of exports. Moreover, the exports of FIEs are less sensitive to the firm's access to external finance from financial intermediaries. All of these findings are robust to different measures and econometric settings.

Our work enriches our understanding of impact of productivity on exports. Productivity could affect exports through credit constraints. Different productivity levels induce different project-specific success probabilities. Observing this, financial intermediaries prefer to extend financing to projects with less risk, given the same levels of principal and repayment. Thus, firms with higher productivity face less severe credit constraints and are able to export and to export more. In short, higher productivity leads to easier access to external finance, and, consequently, to more exports.

Our work contributes to the literature in three important ways. First, our theoretical model suggests that project-specific risk leads to different levels of credit constraints faced by firms. Secondly, empirically, we offer firm-level evidence that credit constraints are an important determining factor of a firm's exports. Firms with easier access to external finance or alternative sources of funds face fewer credit constraints, and, consequently, they export more. Thirdly, we offer evidence that foreign capital inflow affects firms' exports through credit constraints.

Several extensions and possible generalizations merit special consideration. One of them is to consider outward foreign direct investment (FDI) into the model in the sense that firms with higher productivity would perform outward FDI in addition to exports. Another possible extension is to consider how policy shocks like exchange rate changes affect a firm's exports and FDI decisions in the presence of credit constraints. These are the topics that we will pursue in the future.

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Table 1: Summary Statistics (2000-2007)
Panel A: Basic Statistics for Key Variables

Variables	Obs.	Mean	Std.Dev.	Min	Max
Year	1,294,596	2,004.348	2.244	2000	2007
Firm's Exports	1,294,596	17303.12	334,443.5	0	1.81e+08
Firm's Interest Expenditure	1,294,596	1198.837	14325.02	0	5,363,291
Log Exports ($\ln EX_{it}$)	360,106	9.516	1.691	0	19.014
Log Interest Expenditure ($\ln IE_{it}$)	872,208	5.398	1.896	0	15.495
Log Domestic Profits in Previous Year	525,533	6.533	1.905	0	17.557
Log TFP (Olley-Pakes) in Previous Year	840,826	-.031	.322	-9.746	2.444
Log Labor Productivity in Previous Year	846,495	5.250	.999	-1.421	13.417
Log Ratio of Exports to Sales	360,106	-965	1.412	-15.194	3.890
Log Ratio of Interest Expenditure to Sales	872,208	-4.888	1.512	-15.704	2.486
Log Ratio of Domestic Profits to Sales	812,966	-3.564	1.446	-13.147	3.338
SOEs Dummy (all scale)	1401,569	.091	.288	0	1
SOEs Dummy (above scale: SOE_i)	1,294,596	.058	.234	0	1
FIEs Dummy (inclusive H/M/T: FIE_i)	1,294,596	.211	.408	0	1
FIEs Dummy (exclusive H/M/T)	1,294,596	.102	.303	0	1
$FIE_i \times \ln IE_{it}$	872,208	1.038	2.355	0	15.495
$SOE_i \times \ln IE_{it}$	872,208	.444	1.732	0	14.600
WTO Dummy	1,294,596	.857	.350	0	1
Money Supply (M1)	1,294,596	1.51e+10	3.17e+09	5.31e+09	1.53e+10
Weight of Firm's Scale ($l_{ijt-1}/\sum_{i\in j} l_{ijt-1}$)	846,495	.000	.001	3.07e-07	.040
Log Weighted Money Supply	846,495	11.484	1.271	7.398	19.773

Panel B: Simple Correlations for Some Key Variables

	Log Exports	Log Interest Expenditure	Log Lag TFP	Weighed M1
Log Exports	1.000			
Log Interest Expenditure	.328	1.000		
Log Lag TFP	.197	.083	1.000	
Weighed M1	.390	.487	.094	1.000

Table 2: Benchmark Estimates, Log of Exports as the Dependent Variable

Regressand	OLS		FE		PPML+FE
Log Firm's Exports ($\ln EX_{it}$)	(1)	(2)	(3)	(4)	(5)
Log Interest Expenditure ($\ln IE_{it}$)	.290**	.170**	.105**	.112**	.351**
	(137.19)	(24.33)	(29.64)	(5.87)	(14,406.35)
Log TFP ($\ln TFP^{OP}_{it-1}$)	.960**	.470**	.215**	.204**	.635**
	(50.69)	(10.81)	(15.99)	(3.05)	(4,422.97)
FIEs Dummy (FIE_i)	.775**	.596**	–	–	–
	(100.29)	(7.81)			
$FIE_i \times \ln IE_{it}$		-.032**		-.007	.087**
		(-2.63)		(-.46)	(12,237.53)
Log Domestic Profit ($\ln Dprof_{it-1}$)		.145**		.008	.386**
		(22.88)		(.70)	(16,775.06)
SOEs Dummy (SOE_i)		-1.650**		–	–
		(-8.59)			
$SOE_i \times \ln IE_{it}$		.174**		-.018	-.023**
		(7.23)		(-1.08)	(-2,326.87)
Firm Fixed Effects	No	No	Yes	Yes	No
Year Fixed Effects	No	No	Yes	Yes	Yes
Observations	178,136	33,492	178,136	33,492	33,493
Root MSE	1.62	1.85	.000	.000	.000
(Pseudo) R-squared	.16	.11	.09	.03	.50

Notes: Robust t-values corrected for clustering at the firm level in parentheses. *(**) indicates significance at the 10(5) percent level. Column (5) is the Poisson pseudo-maximum likelihood (PPML) fixed-effects estimation in which the regressand is $EX_{it} > 0$.

Table 3: IV Fixed-Effects Estimates of Interest Expenditures on Firms' Exports

Regressand:	"Above-Scale" Estimates			"All Scale"
Log Firm's Exports ($\ln EX_{it}$)	Broad FIE	Broad FIE	Narrow FIEs	Estimate
	(1)	(2)	(3)	(4)
Log Interest Expenditure ($\ln IE_{it}$)	.928**	1.068**	1.123**	.753**
	(28.72)	(4.67)	(6.37)	(3.76)
Log TFP ($\ln TFP^{OP}_{it-1}$)	.193**	.156**	.165**	.135
	(13.78)	(2.01)	(2.08)	(1.47)
FIEs Dummy (FIE_i)	–	–	–	–
$FIE_i \times \ln IE_{it}$		-.256**	-.157**	-.178**
		(-4.18)	(-5.26)	(-3.16)
Log Domestic Profits ($\ln Dprof_{it-1}$)		-.006	-.008	.012
		(-.45)	(-.58)	(.81)
SOEs Dummy (SOE_i)		–	–	–
$SOE_i \times \ln IE_{it}$		-.107**	-.098**	-.098**
		(-3.93)	(-4.36)	(-3.32)
Log Weighted M1 (IV in the First-stage)	.717**	.445**	.430**	.475**
	(223.64)	(64.36)	(62.15)	(60.16)
Excluded F Statistic in the First-stage	50,014.16†	4,142.19†	7636.93†	3619.71†
Kleibergen-Paap rk LM statistic	23,282.69 †	2,914.84†	3014.38†	2720.54†
Kleibergen-Paap Wald rk F statistic	50,015.29†	4,143.18†	3862.19†	3620.77†
Anderson-Rubin χ^2 Statistic	25804.69†	1,067.70 †	657.38†	602.62†
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	178,130	33,488	33,493	27,291
Partical R-squared in the 1^{st} Stage	.24	.12	.14	.15
R-squared in the 2^{nd} Stage	.11	.05	.07	.06

Notes: Robust t-values corrected for clustering at the firm level in parentheses. *(**) indicates significance at the 10(5) percent level. † means the p-value is less than 0.01.

Table 4: More Robustness Checks

Regressand:	Without Productivity			Labor Productivity	
Log Firm's Exports ($\ln EX_{it}$)	OLS	FE	FE+IV	FE	FE+IV
	(1)	(2)	(3)	(4)	(5)
Log Interest Expenditure ($\ln IE_{it}$)	.166**	.113**	1.063**	.108**	1.206**
	(23.76)	(5.91)	(4.65)	(5.64)	(7.11)
Log TFP ($\ln TFP^{OP}_{it-1}$)					
Log Labor Productivity ($\ln LP_{it-1}$)				.179**	.057
				(4.75)	(1.30)
FIEs Dummy (FIE_i)	.605**	–	–	–	–
	(7.94)				
$FIE_i \times \ln IE_{it}$	-.030**	-.009	-.257**	-.007	-.295**
	(-.2.55)	(-.53)	(-4.17)	(-.44)	(-6.25)
Log Domestic Profits ($\ln Dprof_{it-1}$)	.167**	.017	.001	.001	-.006
	(27.90)	(1.41)	(.08)	(.07)	(-.46)
SOEs Dummy (SOE_i)	-1.703**	–	–	–	–
	(-8.88)				
$SOE_i \times \ln IE_{it}$	.181**	-.018	-.107**	-.016	-.120**
	(7.53)	(-1.10)	(-3.92)	(-.96)	(-5.01)
Firm Fixed Effects	No	Yes	Yes	Yes	Yes
Year Fixed Effects	No	Yes	Yes	Yes	Yes
Observations	33,604	33,604	33,600	33,604	33,600
Prob.>F	.000	.000	.000	.000	.000
R-squared	.11	.15	.05	.15	.05

Notes: Robust t-values corrected for clustering at the firm level in parentheses. *(**) indicates significance at the 10(5) percent level.

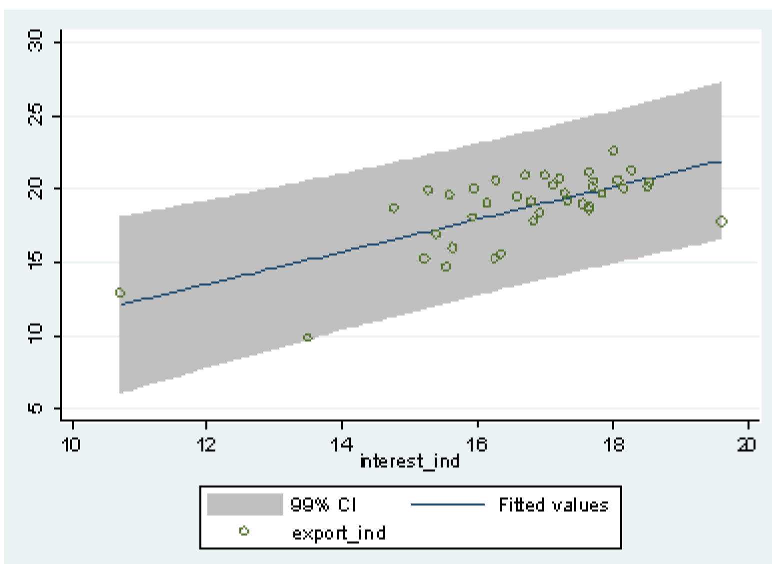
Table 5: Estimates of Ratio Specifications

Regressand:	FE		FE+IV	
Log Ratio of Exports to Sales ($\ln(EX/Sales)_{it}$)	(1)	(2)	(3)	(4)
Log Ratio of Interest Expenditure to Sales ($\ln(IE/Sales)_{it}$)	.019**	.049**	.535**	.562
	(6.66)	(2.77)	(4.64)	(1.16)
Log TFP ($\ln TFP^{OP}_{it-1}$)	.035**	.003	.091**	.062
	(3.73)	(.05)	(5.54)	(.70)
FIEs Dummy (FIE_i)	–	–	–	–
$FIE_i \times \ln(IE/Sales)_{it}$	-.013**	-.024	-.327**	-.272
	(-4.09)	(-1.19)	(-4.66)	(-1.15)
Log Ratio of Domestic Profits to Sales ($\ln(Dprof_{it-1}/Sales_{it})$)		-.051		-.036*
		(-4.21)		(-1.87)
SOEs Dummy (SOE_i)		–		–
$SOE_i \times \ln(IE_{it}/Sales)_{it}$		.019		-.078
		(.73)		(-.81)
Firm Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	178,136	33,492	178,130	33,488
Prob.>F	.000	.000	.000	.000
R-squared	.01	.01	.01	.01

Notes: Robust t-values corrected for clustering at the firm level in parentheses. *(**) means significant at the 10(5) percent level.

Source: Data are from Chinese City Statistical Yearbook, various years

Figure 1A: Log exports vs. Log Inward FDI
at Chinese City Level during 2000-2007



Source: Authors calculation based on the dataset

Figure 1B: Log Exports vs. Log Interest Expenditure
at Two-digit Industrial Level during 2000-2007

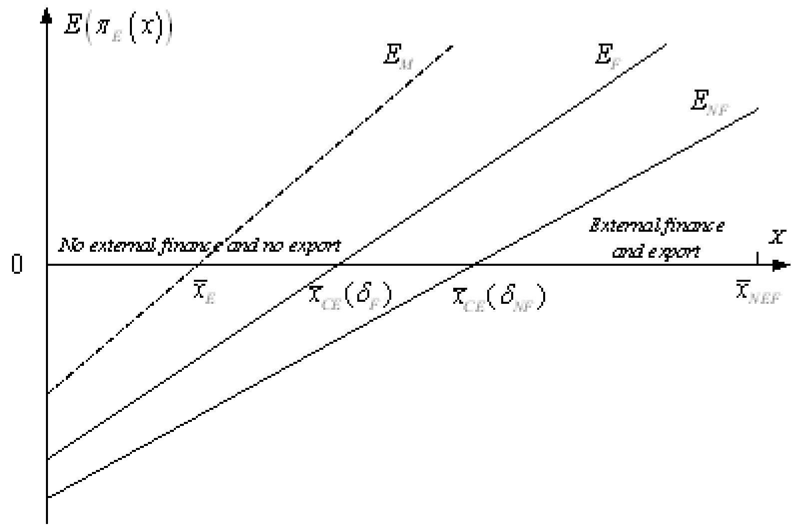


Figure 2: Firm's Productivity, Credit Constraints, and exports

Appendix A: Solving the cutoffs

Domestic cutoff

$$\overline{x}_d^{\sigma-1} = w^{\sigma-1}\frac{\sigma}{\mu L}\left(\frac{\sigma}{\sigma-1}\frac{1}{P}\right)^{\sigma-1}C_d = w^{\sigma-1}\left(\frac{1}{w}\right)^{\sigma-1}\frac{\sigma}{\mu}\int\limits_{x\geqslant\overline{x}_d} x^{\sigma-1}dF_x(x)C_d \equiv h^{\sigma-1}(C_d)$$

- exports cutoff without credit constraints

$$\begin{aligned}\overline{x}_E^{\sigma-1} &= \frac{\sigma}{\mu L^*}\left(\frac{\sigma}{\sigma-1}\frac{\tau w}{P^*}\right)^{\sigma-1}C_E = \frac{C_E}{C_d^*}(\tau w)^{\sigma-1}\left(\frac{\sigma}{\sigma-1}\right)^{\sigma-1}\frac{\sigma}{\mu}\frac{{P^*}^{1-\sigma}C_d^*}{L^*}\\ &= \frac{C_E}{C_d^*}(\tau w)^{\sigma-1}\left(\frac{\sigma}{\sigma-1}\right)^{\sigma-1}\frac{\sigma}{\mu}\int\limits_{x\geqslant\overline{x}_d^*}\left(\frac{\sigma}{\sigma-1}\frac{w^*}{x}\right)^{1-\sigma}dF_x(x)C_d^* = \frac{C_E}{C_d^*}\left(\frac{\tau w}{w^*}\right)^{\sigma-1}h^{\sigma-1}(C_d^*)\end{aligned}$$

- exports cutoff with credit constraints

$$\frac{r_E(\overline{x}_{CE})}{\sigma} - w^*C_E = \left(\frac{1}{\lambda(\overline{x}_{CE})}-1\right)\left((1-\delta_i)\,w^*C_E - d\pi_d(\overline{x}_{CE})\right)$$

$$\frac{r_E(\overline{x}_{CE})}{\sigma} = \frac{(1-\delta_i+\lambda(\overline{x}_{CE})\delta_i)\,w^*C_E}{\lambda(\overline{x}_{CE})} - \left(\frac{1}{\lambda(\overline{x}_{CE})}-1\right)d\pi_d(\overline{x}_{CE})$$

Substituting in revenue and profit, we get

$$\begin{aligned}\overline{x}_{CE} &= \frac{\sigma}{\sigma-1}\left(\frac{\sigma}{\mu}\right)^{\frac{1}{\sigma-1}}\left(\frac{(1-\delta_i+\lambda(\overline{x}_{CE})\delta_i)\,w^*C_E}{\lambda(\overline{x}_{CE})} + \left(\frac{1}{\lambda(\overline{x}_{CE})}-1\right)dwC_d\right)^{\frac{1}{\sigma-1}}\\ &\quad\left(w^*L^*\left(\frac{\tau w}{P^*}\right)^{1-\sigma} + \left(\frac{1}{\lambda(\overline{x}_{CE})}-1\right)dwL\left(\frac{w}{P}\right)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}\end{aligned}$$

In equilibrium, by substituting in P and P^*, we can solve the cutoffs:

$$\begin{aligned}\overline{x}_{CE} &= \left(\frac{(1-\delta_i+\lambda(\overline{x}_{CE})\delta_i)\,w^*C_E}{\lambda(\overline{x}_{CE})} + \left(\frac{1}{\lambda(\overline{x}_{CE})}-1\right)dwC_d\right)^{\frac{1}{\sigma-1}}\\ &\quad\left(w^*L^*\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\frac{\mu}{\sigma}\left(\frac{\tau w}{P^*}\right)^{1-\sigma} + \left(\frac{1}{\lambda(\overline{x}_{CE})}-1\right)dwL\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma}\frac{\mu}{\sigma}\left(\frac{w}{P}\right)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}\\ &= \left(\frac{(1-\delta_i+\lambda(\overline{x}_{CE})\delta_i)\,w^*C_E}{\lambda(\overline{x}_{CE})} + \left(\frac{1}{\lambda(\overline{x}_{CE})}-1\right)dwC_d\right)^{\frac{1}{\sigma-1}}\\ &\quad\left(w^*C_d^*(\tau w)^{1-\sigma}\left(\frac{1}{w^*}\right)^{1-\sigma}h^{1-\sigma}(C_d^*) + \left(\frac{1}{\lambda(\overline{x}_{CE})}-1\right)dw^{2-\sigma}C_d\left(\frac{1}{w}\right)^{1-\sigma}h^{1-\sigma}(C_d)\right)^{\frac{1}{1-\sigma}}\\ &= \left(\frac{(1-\delta_i+\lambda(\overline{x}_{CE})\delta_i)\,\frac{w^*}{w}C_E + (1-\lambda(\overline{x}_{CE}))\,dC_d}{\lambda(\overline{x}_{CE})\tau^{1-\sigma}\left(\frac{w^*}{w}\right)^{\sigma}C_d^*h^{1-\sigma}(C_d^*) + (1-\lambda(\overline{x}_{CE}))\,dC_dh^{1-\sigma}(C_d)}\right)^{\frac{1}{\sigma-1}}\end{aligned}$$

Appendix B: TFP Calculation by the Olley-Pakes (1996) Approach

One of the most important features of the Olley-Pakes approach is to model investment as a function of unobserved productivity as well as capital input. By assuming that three factor inputs (*i.e.*, capital, labor, and material) are used to produce goods, the Olley-Pakes estimation method includes three steps. First, a semi-parametric empirical method is used to estimate the coefficients of both labor and material inputs. In particular, the unobserved productivity shock is modeled as an inverse function of investment, which is characterized by a fourth-order polynomial. Given China's WTO accession in 2001, which was a positive demand shock for China's exports, we also include the WTO dummy in this polynomial to capture the effect of the WTO accession. In particular, we consider a polynomial $g(.)$ as following:

$$g(k_{it}, I_{it}, EF_{it}, WTO_t) = (1 + WTO_t + EF_{it}) \sum_{h=0}^{4} \sum_{q=0}^{4} \theta_{hq} k_{it}^h I_{it}^q,$$

where the polynomial depends on capital k, investment I, the dummy of the exporting firm EF, and a WTO dummy that equals one since 2002. The coefficients $\theta_{hq,} \forall h, \forall q$ are of interest to estimate. For a more detailed introduction to this approach, see Yu (2008).

Second, after the coefficients of labor and material inputs are obtained, the coefficient of capital can be estimated by using a non-linear square estimation. In this way, Olley and Pakes (1996) show that the simultaneity problem is well controlled. Third, to control the selection bias problem, we first use a probit function to estimate the probability of a firm's survival in the next period. Once the fitted value of firms' survival ratio is obtained, we put it into the inverse investment function once again to estimate all the three input coefficients. Finally, the residual between the data and the fitted value obtained from the three estimated input coefficients is the Olley-Pakes TFP.

Appendix Table A: Main Notation for the Models

Symbol	Definition
	Panel A: Theoretical Framework
q_0	Quantity of homogeneous good
ω	Variety of differentiated good
Ω	Overall set of varieties available to the consumer
σ	Elasticity of substitution between differentiated goods, $\sigma > 1$
μ	Expenditure share in homogeneous good
p	price of each variety
P	Price index of countries
L, L^*	Home and foreign population
$r(\omega)$	Revenue of each firm producing variety ω
C_d, C_E	Fixed entry cost of domestic market and exports market
w, w^*	Home and foreign wage
x	Firm's productivity
π	Profit
λ	Success possibility of project
G	Repayment demanded by financial intermediaries
δ_i	The portion of fixed entry cost financed by alternative external fund
t	The fraction of the domestic fixed cost pledgeable as collateral
τ	Iceberg transportation cost
d	The fraction of the domestic profit used as internal finance
	Panel B: Empirical Specification
l_{ijt}	Number of employees of firm i in industry j in year t
$M1$	China base money supply
ς_i	Firm-specific fixed effect
ϑ_t	Year-specific fixed effect
ϵ_{it}	Idiosyncratic error term

Appendix Table B: Total Factor Productivity of Chinese Plants

Industry (code)	Est.	Labor		Materials		Capital	
	Prob.	OLS	OP	OLS	OP	OLS	OP
Mining & Washing of Coal (6)	.992	.063	.043	.834	.813	.059	.081
Mining & Processing of Ferrous Metal Ores (8)	.998	.096	.092	.872	.898	.040	.038
Mining & Processing of Non-Ferrous Metal (9)	.999	.058	.072	.889	.876	.042	.101
Mining & Processing of Nonmetal Ores (10)	.995	.083	.066	.819	.791	.044	.099
Processing of Food (13)	.994	.068	.043	.833	.890	.048	.058
Manufacture of Foods (14)	.995	.057	.058	.850	.840	.049	.023
Manufacture of Beverages (15)	.994	.089	.068	.820	.855	.052	.044
Manufacture of Tobacco (16)	.999	.053	.048	.848	.854	.161	.182
Manufacture of Textile (17)	.994	.066	.056	.863	.879	.033	.036
Manufacture of Apparel, Footware & Caps (18)	.993	.100	.096	.792	.796	.053	.019
Manufacture of Leather, Fur, & Feather (19)	.989	.082	.082	.846	.842	.043	.078
Processing of Timber, Manufacture of Wood, Bamboo, Rattan, Palm & Straw Products (20)	.989	.074	.051	.841	.881	.038	.045
Manufacture of Furniture (21)	.989	.107	.154	.802	.732	.046	.077
Manufacture of Paper & Paper Products (22)	.990	.066	.061	.851	.849	.044	.048
Printing, Reproduction of Recording Media (23)	.994	.088	.063	.796	.847	.068	.052
Manufacture of Articles For Culture, Education & Sport Activities (24)	.991	.086	.068	.822	.827	.049	.045
Processing of Petroleum, Coking, &Fuel (25)	.992	.035	.041	.864	.906	.062	.061
Manufacture of Raw Chemical Materials (26)	.991	.053	.031	.830	.857	.063	.074
Manufacture of Medicines (27)	.990	.101	.064	.785	.803	.060	.002
Manufacture of Chemical Fibers (28)	.995	.047	.029	.901	.923	.028	.032
Manufacture of Rubber (29)	.996	.078	.089	.801	.729	.067	.142
Manufacture of Plastics (30)	.994	.079	.074	.821	.816	.056	.051
Manufacture of Non-metallic Mineral goods (31)	.993	.049	.038	.858	.870	.040	.870
Smelting & Pressing of Ferrous Metals (32)	.991	.054	.043	.891	.921	.036	.036
Smelting & Pressing of Non-ferrous Metals (33)	.995	.052	.038	.887	.889	.031	.052
Manufacture of Metal Products (34)	.994	.078	.102	.793	.710	.067	.063
Manufacture of General Purpose Machinery (35)	.995	.066	.049	.827	.835	.057	.058
Manufacture of Special Purpose Machinery (36)	.993	.067	.029	.809	.868	.060	.070
Manufacture of Transport Equipment (37)	.992	.086	.077	.809	.804	.065	.058
Electrical Machinery & Equipment (39)	.996	.085	.068	.812	.833	.063	.119
Manufacture of Communication Equipment, Computers & Other Electronic Equipment (40)	.994	.103	.094	.776	.785	.082	.148
Manufacture of Measuring Instruments & Machinery for Cultural Activity & Office Work (41)	.992	.089	.049	.724	.815	.096	.050
Manufacture of Artwork (42)	.992	.084	.073	.821	.849	.046	.045
Electric Power & Heat Power (44)	.996	.156	.140	.611	.590	.219	.217
Production & Supply of Gas (45)	.999	.072	.035	.653	.558	.184	.275
Production & Supply of Water (46)	.981	.046	.019	.671	.636	.172	.163
All industries	.993	.068	.061	.825	.828	.062	.075

Notes: I do not report standard errors for each coefficient to save space, which are available upon request.